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the fuel and burns in the *combustion chamber*. The burning gases expand enormously and rush through the turbine, spinning the *turbine wheels*. Part of the rotary power from the turbine wheels drives the air compressor. This compressor is often mounted on the same shaft as the wheels. The rest of the rotary power can turn electric generators, run pumps, or drive ships.

Gas turbines are designed to make use of their hot exhaust gases. For example, a gas turbine used to turn an electric generator has a waste-heat recovery device called a *regenerator*. The regenerator uses heat from the exhaust gases to warm up the high-pressure air from the compressor before it enters the combustion chamber. By preheating the air, the regenerator reduces the amount of fuel needed for the combustion process. Other types of gas turbines, including turbojet and turbofan engines for aircraft, use the energy from exhaust gases for power. The gases are forced out the tailpiece of such turbines at high speed to produce forward thrust. See JET PROPULSION.

Gas turbines run at even hotter temperatures than steam turbines do. Engineers must make gas turbines from metals that keep their strength and shape in heat that would weaken steel. The temperature in many gas turbines is 2,000° F. (1093° C) or higher. The hotter a gas turbine runs, the more efficiently it operates. But a gas turbine works best only when run at from three-fourths of full power to full power. This can be a disadvantage when the turbine is used to propel ships, which often must move slowly. Gas turbines are usually very light and small for the power that they produce. For example, gas turbines that are used on land and in ships produce 3,000 to 30,000 horsepower (2,200 to 22,000 kilowatts), and they have an average weight of from 5 to 15 pounds per horsepower (3 to 9 kilograms per kilowatt).

History

Early Days. Water wheels are so old that no one knows who invented them. The ancient Greeks, Egyptians, and other peoples in the Mediterranean area used water wheels to grind grain and to irrigate crops.

Hero of Alexandria described the first known steam turbine about A.D. 60. It consisted of a small metal globe mounted on a pipe leading from a steam kettle. Steam from the kettle escaped from two pipes fastened to opposite sides of the globe and whirled it around. See JET PROPULSION (picture: The First Jet Engine).

Windmills first came into use in the Middle East in the 900's and in Europe in the 1100's. In the 1600's, people built the first crude gas turbines by mounting fans over a cooking fire to turn roasting meat on a spit. The hot gases from the fire spun the fan. Gears connected the fan to the spit.

These first forms of the turbine worked inefficiently, because much of the flowing fluids escaped around the sides of the turbine wheels. Benoît Fourneyron (1802-1867), a French engineer, developed the first fully successful enclosed water turbine in 1832. It developed 50 horsepower (37 kilowatts) and drove hammers used to forge metal. After Fourneyron's success, engineers soon overcame most of the problems that were involved in building efficient water turbines. By 1855, a Paris waterworks had a turbine that provided 800 horsepower (600 kilowatts).

Carl Gustaf de Laval (1845-1913), a Swedish engineer, built an impulse steam turbine in 1883 to power a cream separator he had invented. One year later, Charles A. Parsons (1854-1931) developed a reaction steam turbine in England. About 1900, Charles G. Curtis (1860-1953), an American inventor, developed the first steam turbine using many sets of wheels. The first big Curtis turbine was installed at an electric-power plant in Chicago in 1903. It ran a generator that produced 5,000 kilowatts of electricity. This Curtis turbine started a revolution in power production. It took up one-tenth as much space as the steam piston engine it replaced, weighed one-eighth as much, cost one-third as much, and used less steam. French and Swiss engineers also did important pioneering work on steam turbines.

Recent Developments include the perfection of the gas turbine during World War II. Gas turbines could not be built until engineers learned how to make metals that could withstand the great heat inside the combustion chamber. Gas turbines are now used in electric-power plants, pipeline pumping stations, and heavy industry. They power ships and experimental cars and trucks. In 1963, the Chrysler Corporation tested 50 gas-turbine powered cars.

Engineers have designed and built steam turbines capable of using steam at pressures of more than 4,500 to 5,000 pounds per square inch (316 to 350 kilograms per square centimeter). Such high-pressure steam enables turbines to produce more power with less fuel. In 1957, the American Gas and Electric Company installed a turbine at its Philo, Ohio, plant that uses steam at a pressure of 4,500 pounds per square inch (316 kilograms per square centimeter) and a temperature of 1150° F. (621° C). This power station can produce a kilowatt-hour of electricity from only about $\frac{3}{4}$ pound (0.3 kilogram) of coal. The average power plant burns about 1 pound (0.5 kilogram) of fuel to produce one kilowatt-hour of electricity. Engineers also have designed more powerful steam turbines by combining two or more rotors, so that several turbines become in effect one machine.

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Critically reviewed by J. T. RETTALIATA

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Outline

Questions

Do turbines create power? Explain your answer.
In what ways can a pinwheel turbine be improved?
What are the two main kinds of water turbines?
What is the purpose of a condenser in a steam turbine?
Why were gas turbines not perfected until as recently as World War II?
What are the parts of a turbine rotor?
What are four basic kinds of turbines?
What serious disadvantage does a gas turbine have when it is used to drive a ship or locomotive?
What are the major uses of turbines?
Who invented the first steam turbine? How did it work?